On-Road Sensing Technology for Alternative Fuel Vehicle Emissions

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Objective

On-road measurements of automobile exhausts by remote sensing offer a number of advantages over the more invasive and time-consuming dynamometer test procedures. The reliability of the existing remote sensing systems using nondispersive infrared absorption has been the subject of some controversy. In particular, difficulties are encountered in measuring the all-important NO_x emissions and in avoiding interferences in the CO and hydrocarbons measurements.

The objective of this study is to overcome these difficulties by using telecommunication type tunable diodes lasers as the light source in a remote sensing system.

LASAIR on-road monitoring system.

In addition to the good sensitivity tunable diode laser, absorption spectroscopy provides the most specific analytical technique available at present with virtually no possibility of interferences between emission gases. Because the laser can be scanned across the selected absorption line in milliseconds, very good time resolution is possible.

Approach

The temperature of the laser diode is maintained with a thermoelectric cooler, both of which are housed in a small control unit. The control unit also contains the laser control and the data acquisition systems and a 10-cm cell that contains the gases being measured. This reference cell is used to lock the lasers on to the selected absorption line and to act as a calibration standard. The laser beam is brought by an optical fiber cable to a small 4-in telescope where it is launched across the road to a retroreflector that reflects the beam back into the telescope and then, via an optical cable to the control box for analysis and data processing. Figure 1 shows a photograph of the components of a LASAIR system.

When the vehicle crosses the invisible laser beam it signals the start of the event. If the CO_2 level does not increase above the average value before the event it is not record to distinguish against non-vehicular interruption of the beam by, for example, people walking across it. Emission measurements are taken and averaged for 0.1-second periods after the start of the event. All measurements are reported as concentrations relative to CO_2

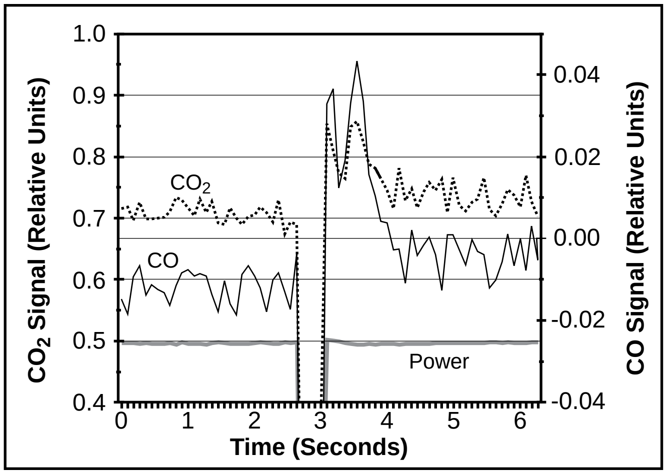

Figure 2: Raw data obtained by the LASAIR-R remote vehicle emissions monitor for the Ford Aerostar test vehicle traveling at 25 mph with λ = 0.8. CO/CO_2 = 0.858 from the data averaged over 0.5 sec after the vehicle passed the test point.

to account for the location of the beam relative to the tailpipe and the fluctuations caused by turbulence. Figure 2 shows the real-time variation in the CO and CO_2 signals measured during a vehicle pass-by.

Accomplishments

Following successful laboratory and dynamometer demonstrations, the LASAIR near infrared tunable diode laser system has been evaluated at the Ford Motor Company Dearborn Proving Grounds facility in Dearborn, Michigan during June 1994. The Aerostar van had on-board instrumentation for continuously measuring the emissions and a number of engine operating parameters. Testing was conducted at speeds of 15 to 35 mph, air/fuel ratios referenced to stoichometry (λ) between 0.8 and 1.0 and with the gear set in 1st, 2nd, or 3rd during a pass by. This provided CO emissions of 0.05% to ~ 8%. More than 120 passes were monitored to provide a comprehensive data set with a minimum of six measurements under identical conditions for statistical validation.

Comparison measurements were made with the instrumented Ford Aerostar test vehicle. The correlation between the CO/CO_2 ratios measured by the LASAIR and the on-board Aerostar CO/CO_2 measurements was very good (R^2>0.95%). The average slope of the regression line was 1.0 with a maximum deviation of 3%. The sensitivity of the LASAIR was excellent; a good signal/noise ratio was obtained for all engine operating conditions. Figure 3 shows the correlation plot of the CO/CO_2 ratios measured by the on-board instrumentation and the LASAIR at 30 mph.

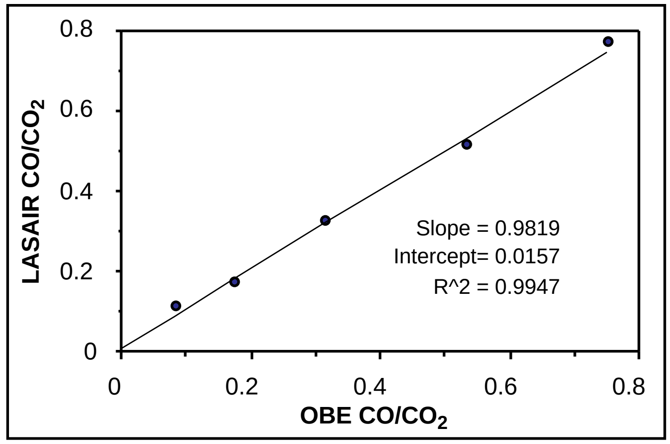

Figure 3: Comparison of the CO/CO_2 ratio measured by the LASAIR with the on-board FTIR CO/CO_2 taken on the Ford Motor Company Test Track at Dearborn, MI The speed was set to 30 mph and lambda was varied between 0.80 and 1.0. Data obtained at 10 Hz has been averaged over the time (~0.5 sec) during which the exhaust plume impacted the measurement path.

Future Direction

A laser diode has been acquired for NO measurements and is being installed into the system. Intercomparisons studies with the Ford Aerostar test vehicle will be performed soon at the Dearborn MI Proving Ground facilities. Following a successful series of tests, design and construction of a multicomponent instrument (NO, CO, CO_2) will be undertaken.

Publications

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